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ABSTRACT

In March, 1973, after a review of the Ontario universities' three-year plans, a provisional embargo was placed on doctoral work in biophysics. A full-scale assessment with outside consultants was not necessary in the case of a provisional embargo. Instead, the method used to remove the embargo was self-study by the discipline group leading to a report to the Advisory Committee on Academic Planning (ACAP), which, in turn, makes recommendations to the Council of Ontario Universities (COU). The report is one of a series of disciplinary studies whose emphasis is on forward planning, and it is hoped that the implementation of COU's recommendation will help to ensure the more ordered growth and development of graduate studies in Ontario's universities. The monograph includes the "Biophysics Planning Study" containing specific recommendations concerning biophysics graduate studies; the graduate programs established and proposed in Ontario prepared by the discipline group; and the universities' comments. (Author/JMF)

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Conseil des Universités de l'Ontario

PERSPECTIVES AND PLANS FOR GRADUATE STUDIES

16. BIOPHYSICS 1974

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F O R E W O R D

The Advisory Committee on Academic Planning (ACAP), as presently constituted, was established by the Ontario Council on Graduate Studies at the request of the Council of Ontario Universities in January, 1971. The Advisory Committee's terms of reference were directed broadly toward the effective planning and rationalization of long-term graduate development in Ontario's universities both at the level of individual disciplines and at a more general level. The Advisory Committee's activities are based on the premise that graduate work is the one area of university activity in which specialization among universities, cooperative arrangements and comprehensive planning are most necessary.

In March, 1971, concern over the rising costs for support of graduate work prompted the Ontario government to institute a general embargo on funding for any new graduate programme, that is, one which had no students enrolled on May 1, 1971. This embargo was subsequently modified to include only those disciplines in which over-expansion was felt to be potentially most serious. ACAP was to begin immediately planning studies in those disciplines which remained embargoed.

It was also arranged that there would be a re-examination annually to discover if the universities' plans for new programmes for the next three years would justify any changes in the list of disciplines under embargo. When this was done in the Autumn of 1972, it was found that there were a number of disciplines for which a study was clearly indicated but for which it seemed undesirable to use full-scale apparatus of a "planning assessment" with a team of external consultants. Such disciplines were put under "provisional embargo", which implied that the embargo would be lifted as the result of a less formal examination of future plans, conducted under the auspices of ACAP.

The decision as to whether "embargo" or "provisional embargo" was appropriate depended on many factors, including the number of universities involved, the likelihood of obtaining a convincing result without external quality appraisal, and the need for speed in reaching agreement on a plan.

The most advantageous technique for carrying out the study to raise a provisional embargo varies from case to case. In the case of biophysics programmes, it was decided to ask the Discipline Group (one biophysicist from each interested university) to do much of the work normally assigned to consultants.

The following report is one of a series of disciplinary planning studies carried out by the Advisory Committee on Academic Planning and to be published by the Council of Ontario Universities. The emphasis of the report is on forward planning, and it is hoped that the implementation of COU's recommendations will help to ensure the more ordered growth and development of graduate studies in Ontario's universities.

* * *

The following planning principles which were established by COU for dealing with the more formal planning assessments apply also to the more ad hoc planning studies, except for clearly inapplicable references such as the mention of consultants.

1. Discipline assessments by ACAP should form the basis for planning by the universities of their development of graduate studies, particularly PhD programmes. On the basis of these assessments, COU should make its own recommendations on currently embargoed programmes. Each university must retain the freedom and responsibility to plan and implement its own academic development. However, the universities in embarking on a cooperative planning process have signalled their intentions of cooperating with the COU recommendations.

2. Universities generally plan their emphases in graduate study on the bases of related departments, not of single departments. Initially the sequential nature of the discipline planning assessments makes this difficult. On the information and recommendations available, each university should be able to make decisions concerning its support of graduate programmes in these areas. Amendments to university responses to the individual discipline planning assessments may then be made in the wider context of a group of related disciplines and amendments to COU's original Reports on an individual discipline may be required.

3. The first concern in planning is to review the quality of graduate opportunities and of students in Ontario universities and to make judgements about how to proceed or not proceed based on quality considerations. The procedures have made use of highly qualified independent consultants who have no direct interest in the universities in Ontario. Accordingly, COU feels bound to accept their judgements about quality where they are stated clearly unless unconvinced that their conclusions about quality are consistent with their evidence. COU's recommendations in the case of programmes which are of unsatisfactory or questionable quality will call for discontinuation or the carrying out of an appraisal, if the continuation of the programme is not crucial to the province's offerings. In some cases, however, there may be a particular need for the programme and the appropriate recommendation will be to strengthen it, with an appraisal following that action. It is also possible that if there were found to be too large a number of broadly-based programmes there could be a recommendation to discontinue the weakest; in this case, an appraisal for a more limited programme might be relevant.

4. A second consideration is the scope of opportunities for graduate work in the discipline. Do the Ontario programmes together offer a satisfactory coverage of the main divisions of the disciplines?

5. Numbers of students to be planned for will depend on the likely number of applicants of high quality and in some cases may relate to an estimate of society's needs. Such estimates may be reasonably reliable in some cases and not in others. If the plans of the universities appear to be consistent with the likely number of well-qualified applicants and there is either no satisfactory basis for estimating needs or there is no inconsistency between a reasonable estimate of need and the universities' plans, then COU will take note of the facts without making recommendations on the subject of numbers.

   If the numbers being planned for by the universities are grossly out of line with the anticipated total of well-qualified students, or a reliable estimate of needs, COU will make appropriate corrective recommendations. Depending on the circumstances, these may call for a change in the total numbers to be planned for and indications of which institutions should increase, decrease, or discontinue. The recommendations in serious cases may need to specify departmental figures for each university for a time. If the numbers being planned for are insufficient, the recommendations may call for expansion, or new programmes, and may have implications for both operating and capital costs.

   Unless there are exceptional circumstances, the recommendations concerning enrolment will not call for a university to refuse admission to any well-qualified student who wishes to work in a field in which that university offers a programme and in which it has the capacity to accommodate the student.

6. The quality of graduate programmes is partly dependent on size, and for each programme, depending on how it is designed and its scope, there is a minimum size of enrolment below which quality may suffer. That number cannot be expressed for the discipline as a whole but only for individual programmes depending on their purpose, their resources and their design.

7. Universities will be expected to notify COU if they intend to depart from the COU Report in any way which they believe might have a significant bearing on the provincial plans.

8. Appraisals arising as the result of assessments are to be based on the standards but not necessarily the scope of the acceptable programmes in the province.

Council of Ontario Universities
Conseil des Universités de l'Ontario

Report and Recommendations concerning Graduate Studies in Biophysics

In March, 1973, after a review of the universities' three year plans, a provisional embargo was placed on doctoral work in biophysics. A full-scale assessment with outside consultants is not necessary in the case of a provisional embargo. Instead, the method used to remove the embargo is self-study by the discipline group leading to a report to ACAP, which, in turn, makes recommendations to COU.

ACAP has conducted the necessary study in the manner outlined in the attached report.

COU has accepted this report.

When the provisional embargo was established, both Carleton and Guelph had proposed to begin doctoral work in biophysics but during the course of the study Carleton withdrew its proposal.

It is recommended that:

1. Interested universities develop interuniversity cooperation, particularly in the area of the formal teaching programme of graduate students in biophysics. Qualified individuals or small biophysics groups in universities without appropriate PhD programmes be enabled to supervise PhD candidates in cooperation with an appraised group or programme subject to conditions that include the following:

   a) the candidates meet the academic requirements of the degree-granting university.

   b) the supervisory committee of the student include faculty from both universities.

   c) residency requirements be modified, if necessary, to allow the candidate's research to take place on his supervisor's campus.

   d) there be a fair sharing of costs and income.

2. The universities plan for modest growth in enrolment in biophysics at the graduate level.

3. Brock University continue its master's work in biophysics in its Department of Biological Sciences according to its plans.

4. The University of Guelph continue to prepare students on research topics of a biophysical character leading to master's degrees in its various departments and commence to offer master's and doctoral work specifically in biophysics subject to favourable appraisal, and in accordance with its plans except that the university is advised to anticipate a smaller PhD enrolment than its tabled plans indicate.

5. McMaster University continue its MSc programme in biophysics and its doctoral work in biophysics in its Biology Department according to its plans.

6. The University of Toronto continue to prepare students on research topics of a biophysical character leading to degrees in botany, zoology and certain medical departments and continue the master's and doctoral programmes in its Department of Medical Biophysics according to its plans.

7. The University of Waterloo continue its master's and doctoral programmes in biophysics in its Department of Physics according to its plans.

8. The University of Western Ontario continue its master's and doctoral work in its Biophysics Department according to its plans.

9. York University continue its master's and doctoral work in biophysics in its Department of Biology according to its plans.

10. In view of the acceptance of these recommendations by COU, OCUA request the Minister to remove the provisional embargo on doctoral work in biophysics.

ADVISORY COMMITTEE ON ACADEMIC PLANNING

ONTARIO COUNCIL ON GRADUATE STUDIES

REPORT TO THE COUNCIL OF ONTARIO UNIVERSITIES

ON

BIOPHYSICS PLANNING STUDY

March 14, 1975.

PROCEDURE

From its annual review of the three-year proposed programme reviews submitted by the universities, the joint COU/CUA Committee on Goals and Policies for Graduate Development found that two universities, Carleton and Guelph, proposed to begin graduate work in biophysics. In his letter of March 27, 1973, the Minister indicated that biophysics, at the doctoral level, had been placed under provisional embargo.

A discipline group was formed during the summer of 1973, and its first meeting was called for September 10. The discipline group was given the terms of reference of a typical consultant group and asked to carry out a similar planning study of its discipline to the best of its ability. ACAP realized the discipline group would not be able to make the hard judgements of quality sometimes necessary in discipline assessments. Data were collected and the discipline group met through the winter and spring, and in June, 1974, a draft was sent to the universities for final perusal as to accuracy of data before it became the final report. This report, attached as Appendix A, was mailed out in September for official university comments and these were due on November 1, 1974. These comments appear as Appendix B.

A subcommittee of ACAP met to draft the ACAP recommendations to COU. They are based on the discipline group's report and the universities' comments. As is required, ACAP reports directly to COU. Its report has been transmitted, as well, to the Ontario Council on Graduate Studies and the Council of Deans of Arts and Science for information.

NATURE OF THE STUDY

As was stated in the introduction, two universities, Carleton and Guelph, proposed to begin doctoral work in biophysics. These would join the formal master's and doctoral programmes at Toronto and Western Ontario and the master's programme at McMaster. The other universities, Brock, Guelph, Waterloo, York, and McMaster at the doctoral level offer biophysics training in either their biology or physics departments, the degree being in either of those subjects. Guelph proposes to offer a doctoral programme in its Department of Physics. During the course of the study, Carleton officially withdrew its plans for biophysics work at the doctoral level.

Since the embargo was of the provisional type, a full-scale planning assessment was not required and self-study by a discipline group of biophysicists was felt to be the best method. An outside consultant was not thought necessary in this case, after a preliminary look at the situation revealed the probabiltiy that the discipline group could produce a coherent plan for biophysics in the province.

This report makes no attempt to deal with work of a biophysical nature done in other university departments. The work discussed in this report is that identified as leading to biophysics degrees.

GENERAL RECOMMENDATIONS

Biophysics is essentially interdisciplinary and its departments have often developed around a small group. A very interesting discussion of the character and development of biophysics is given on pages A1 to A3 of the discipline group's report. Biophysics grew around a few prominent individuals working on specific problems involving physics and biology.

The discipline group's report states that "large university departments committed to covering the whole area (of biophysics) do not exist." A list of specialties covered by each department is found beginning on page A8. Most faculty in the province are doing research in either molecular or in cellular biophysics or both, some work in the physiological or in clinical areas and a few in theoretical or in environmental biophysics.

As is normal practice, any university planning to begin doctoral work in a new field is to consult ACAP and the discipline group to obtain planning approval as well as submitting the new proposal to the Appraisals Committee. (It will be recalled that in some circumstances the Appraisals Committee will decide that a formal appraisal is not required.)

Although ACAP appreciates that biophysics grew, in some cases, from one-man departments, such programmes nowadays are unrealistic. "Single individuals of high research calibre should be allowed to supervise biophysics graduate students" but not in a programme of his own. He should become part of a programme at a university that has a recognized, coherent graduate programme in biophysics in which any student he supervises can be registered. Thus interuniversity cooperation becomes of utmost importance in providing for these single, high-calibre professors to take part in training Ontario graduate students.

An interuniversity course involving Brock, Guelph, McMaster and Waterloo with an enrolment of 12 students has been operating for the last two years and has been successful. Efforts like this should be encouraged and expanded. Exceptional professors should not be barred from participating in the training of graduate biophysics students just because their universities have no biophysics programmes. Every effort should be made to incorporate these individuals in existing programmes.

This theme is further developed on pages A15 and A16 of the discipline group's report and culminates in a recommendation with which ACAP concurs.

Recommendation C1

It is recommended that interested universities develop inter-university cooperation, particularly in the area of the formal teaching programme of graduate students in biophysics. Qualified individuals or small biophysics groups in universities without appropriate PhD programmes be enabled to supervise PhD candidates in cooperation with an appraised group or programme subject to conditions that include the following:

(a) the candidates meet the academic requirements of the degree-granting university.
(b) the supervisory committee of the student include faculty from both universities.
(c) residency requirements be modified, if necessary, to allow the candidate's research to take place on his supervisor's campus.
(d) there be a fair sharing of costs and income.

Current graduate enrolment in the biophysics programmes in the province is about 90 students. The present programmes plan for only modest growth. Some universities are experiencing a drop in the number of qualified applicants. They feel this problem will control the growth and expansion of biophysics, making arbitrary enrolment guidelines superfluous. Surprisingly, Guelph intends to grow from its current 3 students to 28 by 1977-78, a goal which ACAP does not think they will likely achieve in the present situation.

Biophysics attracts high-quality graduate students as is discussed on pages A11 and A12. For example, of 89 students surveyed at Toronto, 53 have held prestigious scholarships.

Graduates are having no trouble obtaining employment as there is a steady demand for biophysicists in industry, government and university. The growing complexity of biological problems facing society suggests this demand will not slacken.

Recommendation C2

It is recommended that the universities plan for modest growth in enrolment in biophysics at the graduate level.

UNIVERSITY RECOMMENDATIONS

BROCK

Biophysics at Brock is taught in the Department of Biological Sciences. They enrol one or two students a year and plan similar enrolments over the next few years. Graduate courses are offered in membrane structure and function, muscle structure and function and molecular development biology. Brock is one of the four universities participating in the interuniversity course of selected topics in biophysics.

Recommendation C3

> It is recommended that Brock University continue its master's work in biophysics in its Department of Biological Sciences according to its plans.

GUELPH

This university has plans to begin graduate biophysics programmes reaching an enrolment of 12 doctoral students and 16 master's after five years of operation. We note however that of the 7 faculty members who will be contributing more than 50% of their time to this new programme, 5 are from the physics department, two are from chemistry, all have only modest publication records and none is of the rank of full professor.* We notice as well that although Guelph proposes a specialization in theoretical biophysics, 6 of the 7 faculty members work in cellular or in molecular biophysics. ACAP therefore recommends that if the present proposal receives a favourable appraisal, the University not anticipate enrolment of more than 5 or 6 PhD students with the same number expected at the master's level.

Guelph plans to specialize in radiation diffraction and scattering from biological systems, study of membranes, radiation damage, plant diseases and environmental health problems. There are plans to initiate a programme to train theoretical biophysicists, of whom there are few in Canada.

Guelph participates in the interuniversity course.

Recommendation C4

> It is recommended that the University of Guelph continue to prepare students on research topics of a biophysical character leading to master's degrees in its various departments and commence to offer master's and doctoral work specifically in biophysics subject to favourable appraisal, and in accordance with its plans except that the university is advised to anticipate a smaller PhD enrolment than its tabled plans indicate.

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* Since the submission of the data for this study, an additional appointment, at the level of full professor, has been made.

McMASTER

McMaster offers a master's degree in biophysics but at the doctoral level the interested biophysics student obtains his degree in biology. There are usually 2 or 3 master's students and 2 doctoral students enrolled. McMaster is a participant in the interuniversity course. Plans call for modest growth due to the increasing popularity of biologically-oriented problems. The main emphasis is on molecular biophysics including protein structure, virology, properties and synthesis of macromolecules, and radiation damage and repair. There are no plans currently for new PhD programmes in biophysics.

Recommendation C5

It is recommended that McMaster University continue its MSc programme in biophysics and its doctoral work in biophysics in its Biology Department according to its plans.

TORONTO

Toronto has a graduate Department of Medical Biophysics that offers both the master's and doctoral degrees in biophysics. Part of the Department is located in the Ontario Cancer Institute and the other part, the Department of Medical Genetics is located in the Medical Sciences Building. Master's enrolment averages about 18 students while the doctoral enrolment has fallen from 40 in 1970-71 to 25 in 1973-74. The department seems to have reached a steady state although Toronto has experienced in the last several years a decline in the number of applicants. Total steady state enrolment is about 50. Interests in this department include radiation studies, cell biology, cellular differentiation, immunology, medical and somatic cell genetics, virology, clinical physics and nuclear medicine.

It should be noted that research of a biophysical nature is presumably being done in the botany and zoology departments and some of this will involve graduate students.

Recommendation C6

It is recommended that the University of Toronto continue to prepare students on research topics of a biophysical character leading to degrees in botany, zoology and certain medical departments and continue the master's and doctoral programmes in its Department of Medical Biophysics according to its plans.

WATERLOO

A student may undertake biophysics graduate training within the Department of Physics at the University of Waterloo. Three biophysics faculty members supervise about 3 master's and 2 or 3 doctoral students each year. There are strong ties with other members of the physics and biology departments including joint research grants and supervision of students, shared research equipment and joint seminars with the bioengineering group. In addition to participating in the interuniversity course, cooperation in the form of joint graduate student supervision and research projects exists between between Waterloo and Guelph and between Waterloo and Western Ontario. We urge that this cooperation continue. Although the group itself is small, cooperation with other departments and universities has strengthened the programme. No expansion is seen in the next few years with regard to the number of biophysics faculty. Radiation biology, membranes, and biophysics of freezing damage to mammalian cells are the main areas of interest in this programme.

Recommendation C7

It is recommended that the University of Waterloo continue its master's and doctoral programmes in biophysics in its Department of Physics according to its plans.

WESTERN ONTARIO

Master's and doctoral degrees in biophysics are offered at Western in its Biophysics Department. Its 17 faculty members supervise about 12 master's and 15 doctoral students each year. Western has no plans to increase the scope of its biophysics programme. Current interests include biomechanics, hemodynamics, cell biology, oxygen transport and metabolism, biological energetics, enzyme kinetics, control systems, nerve membranes, contractile systems, radiation biology and dentistry.

Recommendation C8

It is recommended that the University of Western Ontario continue its master's and doctoral work in its Biophysics Department according to its plans.

YORK

York University offers master's and doctoral programmes in biophysics in its Department of Biology. It annually enrols 4 - 6 master's students and about 5 doctoral students under the supervision of the 5 biophysics faculty members. Future plans call for modest expansion including at most one or two additional faculty members and one or two more students. Research interests are centered around microbial genetics, genetic control mechanisms, DNA repair, radiation biology, mutagenesis and enzymology.

Recommendation C9

> It is recommended that York University continue its master's and doctoral work in biophysics in its Department of Biology according to its plans.

RECOMMENDATION FOR COU ACTION

Recommendation C10

It is recommended that COU adopt the recommendations of this report, and, in the expectation that its members will act in accordance with them, COU inform OCUA that it has adopted these recommendations and request that the provisional embargo on biophysics at the doctoral level be now removed, in accordance with the original announcement of the Minister that new graduate programmes would be embargoed until, for each discipline, a planning study had been conducted.

APPENDIX A

BIOPHYSICS GRADUATE PROGRAMMES, ESTABLISHED AND PROPOSED IN ONTARIO

A REPORT PREPARED FOR ACAP BY THE BIOPHYSICS DISCIPLINE GROUP

September 10, 1974

BIOPHYSICS GRADUATE PROGRAMMES, ESTABLISHED AND PROPOSED IN ONTARIO: A REPORT PREPARED FOR ACAP BY THE BIOPHYSICS DISCIPLINE GROUP

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Note: Specific Recommendations are found on pages A-8, A-11, A-15, A-16, A-18, A-19

I. Introduction

The word "biophysics" sounds as though it should designate a particular subdivision of science. However, people who refer to themselves as "biophysicists" would agree that there is no acceptable definition of biophysics as a discrete scientific speciality. The reason for this lies in the enormous range of studies and problems that can rightfully be called biophysics. In the most general sense, biophysics includes all studies in which the concepts of physics and physical chemistry aid our understanding of living processes at any level of biological organization.

Although it is difficult to define biophysics in terms of its content as a subject, it has become conventional to define biophysicists in terms of their training and professional skills. In their standard textbook "Molecular Biophysics", R. B. Setlow and E. C. Pollard define biophysicists as individuals who, for professional reasons, need both physical and biological insight. The Biophysical Society was founded in 1957 in the United States primarily by people who were trained originally as physicists or physical chemists and who later began work on biological problems. One of the principal aims of most university departments that use the word biophysics in their title is to attract physicists and chemists into biological research and to provide a suitable biological training for these people. However, both the Biophysical Society and biophysics departments also include a significant number of people who were trained first as biologists or medical doctors, but who, either by aptitude or additional training, came to regard themselves as biophysicists. Thus, in practical terms, biophysics is what biophysicists do. A condensed list of topics presented at a recent annual meeting of the Biophysical Society will indicate the current flavour and range of the subject: bioenergetics, contractibility and motility, photobiology, biopolymers, membrane cellular regulatory mechanisms, optical methods and probes, nucleic acid structure and chemistry, theoretical biology, radiation biology, photosynthesis, electrophysiology, muscle proteins, active transport, proteins and protein synthesis, nuclear structure and function in eucaryotes, enzyme catalysis, sensory receptors, electron microscopy and instrumentation. Thus, biophysics subsumes a good deal of physical biochemistry, molecular and cell biology, genetics, radiation biology, physiology and mathematical biology. To compound the problem of definition even further, it must be pointed out that these same research areas are also cultivated by scientists who, for one reason or another, do <u>not</u> regard themselves as biophysicists.

Biophysics began in the 19th century and many famous names appear on the roster of pioneering biophysicists: Julius Mayer, Hermann von Helmholtz and John Tyndall, among others. The field fell into eclipse during the early decades of this century perhaps because the people who <u>might</u> have become biophysicists were attracted by the exciting developments

in atomic physics and the biochemical problems posed by the discovery of enzymes, vitamins and hormones. Present day biophysics derives primarily from the work of a few prominent individuals in the early thirties, for example: A. V. Hill on muscle, W. T. Astbury, J. D. Bernal and F. O. Schmitt on X-ray diffraction of macromolecules, D. Gates and J. R. Loofbourow in photobiology, K. S. Cole, D. W. Bronk and H. K. Hartline on electrophysiology, M. Delbrück and W. Stanley in molecular biology and D. E. Lea, R. E. Zirkle and A. Hollaender in radiation biology. Two pioneering biophysicists of international stature in Ontario are Alan C. Burton at the University of Western Ontario and Harold E. Johns at the University of Toronto. A large fraction of the younger generation of Canadian biophysicists have been trained by these two men, or have served as members of their departments. Thanks largely to their efforts and those of their students, Canada has made many significant contributions to modern developments in biophysical science.

Because biophysics is such a broad field, large university departments committed to covering the whole area really do not exist. The development has tended to be accidental and idiosyncratic, usually depending on the presence of one or two forceful and inspired individuals. The most far reaching developments in modern biology, namely the elucidation of the structure of DNA and proteins, stemmed from the establishment of major research units, one at Kings College, London, and the other at Cambridge where physicists had the opportunity to work in biological problems. The particular areas of specialization in these departments have naturally reflected the interests of their founders. The largest post-war university departments in North America seem to have been built around interest in medical and biological applications of radiation, for example, those of Pollard at Yale, Johns at Toronto and Tobias at Berkeley. Other concentrations of biophysicists, not necessarily emphasizing radiation biology, were formed in the biology departments at Cal Tech and MIT, in the Virus Laboratory at Berkeley and at various government laboratories both in America and Europe. However, these few large departments were more the exception than the rule. Until the mid-sixties Alan Burton had a one-man department at Western, Arthur Solomon was essentially alone at Harvard, and there were small research groups at Stanford under Henry Kaplan and at Illinois under Eugene Rabinowitch and Henry Quastler. Even Zirkle's department at Chicago had only five members in 1960.

Despite this sparse formal development, biophysicists have clearly been in the vanguard of many important modern developments in science. The general pattern has been that pioneering biophysicists have introduced young people to certain lines of research but these second generation people then tend to identify with the particular field of biology in which they work. Many molecular biologists, biophysical chemists, physiologists, microbiologists, geneticists,

biochemists, and radiation biologists might, with full justice, call themselves biophysicists, but often they do not. Because of the idiosyncratic nature of biophysics groups, the fertility of the field despite its generally sparse development and the relative rarity of people with aptitude and talent in both the physical and biological sciences, there would seem to be little need for close governmental supervision or planning in this area. Indeed, one would hope that Ontario universities would provide every opportunity for young physical and biological scientists to strengthen and broaden their general abilities as scientists by research and training in this important interdisciplinary area.

Because of difficulties in defining the precise nature of biophysics and because biophysicists are trained and ultimately work in a wide variety of situations the present discipline group had adopted several somewhat arbitrary definitions and classifications in order to proceed with its assigned task. We have assumed that the primary role of a biophysics training programme is to introduce physicists, engineers and chemists to the problems of biology and medicine and to introduce biologists and medical scientists to the thought processes and technology of physics. We have therefore given attention to programmes where there is a major emphasis on providing such cross fertilization regardless of the formal title given to such programmes or departments. We have, however, deliberately excluded departments of biomedical engineering, feeling that these were outside the scope of our deliberations.

In attempting to subdivide biophysics into major research areas, we have chosen only six convenient broad categories: molecular, cellular, physiological, clinical, theoretical and environmental. As will be seen such categories are far from exclusive and many individuals rightly claim to be working in several. Also, because certain categories may appear to be underrepresented, does not necessarily mean that research in these areas is lacking because it may well be being carried out in departments or by individuals which by our definition fall outside the scope of biophysics. With these assumptions and reservations in mind we can now proceed to define the status of biophysics training programmes in Ontario under a variety of headings using data provided by eight universities: Brock, Carleton Guelph, McMaster, Toronto, Waterloo, Western Ontario and York.

II. Present Status of Biophysics Training in Ontario

A. Speciality Areas and Present Coverage: In attempting to determine the coverage of the various areas of biophysics each staff member was asked to assign his research interests to the six categories. Table 1 lists the six major categories and the number of individuals, by university, working in each area based on a total of 102 staff replies. The table should not be assumed to present relative strengths

in biophysics in the various universities but is only presented as an indication of distribution of research interests. This rider is necessitated because uniform criteria of evaluating research interests were not applied in all universities.

From Table 1 it is apparent that approximately one half of the respondents work either in molecular or cellular biophysics or both, nearly one quarter work in physiological or clinical areas and that relatively few work in theoretical or environmental areas at the present time. It must be stressed, however, that these are only the interest areas of those staff who are or might be significantly involved in training in biophysics, it should not be taken as an overall picture of the biological and medical research interests of the universities. It must also be pointed out that although the major emphasis would appear to be on molecular and cellular biophysics this does not always accurately reflect the ultimate goal of the research. For example, a large proportion of the work carried on in Toronto has as its ultimate aim the prevention, diagnosis and treatment of cancer and a variety of genetically-controlled diseases. Furthermore, it is the feeling of the discipline group that molecular and cellular biophysics provides an excellent training ground for individuals who will ultimately do work in the areas of clinical and environmental biophysics and, therefore, the research orientation of the present staff may not reflect the ultimate research interests of the graduates of the programmes.

TABLE 1

STAFF RESEARCH INTERESTS

No. of Respondents	3	5	31	6	32	3	17	5	
University / Category	Brock	Carl-eton	Guelph	McMaster	Toronto	Water-loo	West-ern	York	Total
Molecular	3	3	14	6	16	1	4	4	51
Cellular	2	3	5	2	23	3	8	3	49
Physiological	2	1	8	-	5	-	11	-	27
Clinical	-	1	4	1	9	-	9	-	24
Theoretical	-	-	3	-	1	-	5	1	10
Environmental	-	-	7	-	1	-	-	-	8

In terms of total staff involvement, none of the departments can be classed as being numerically strong. While the departments at Toronto and Western and the proposed group at Guelph appear to have relatively large staff complements, the majority of the group at Toronto do not hold full-time academic positions and ten of the seventeen staff members at Western hold primary appointments in other departments or outside the University. In spite of these numerical limitations, several of the departments have built world-wide reputations in their fields of expertise. Finally, it should be pointed out that the vast majority of biophysics training in Canada occurs in Ontario with only a few groups in the rest of Canada.

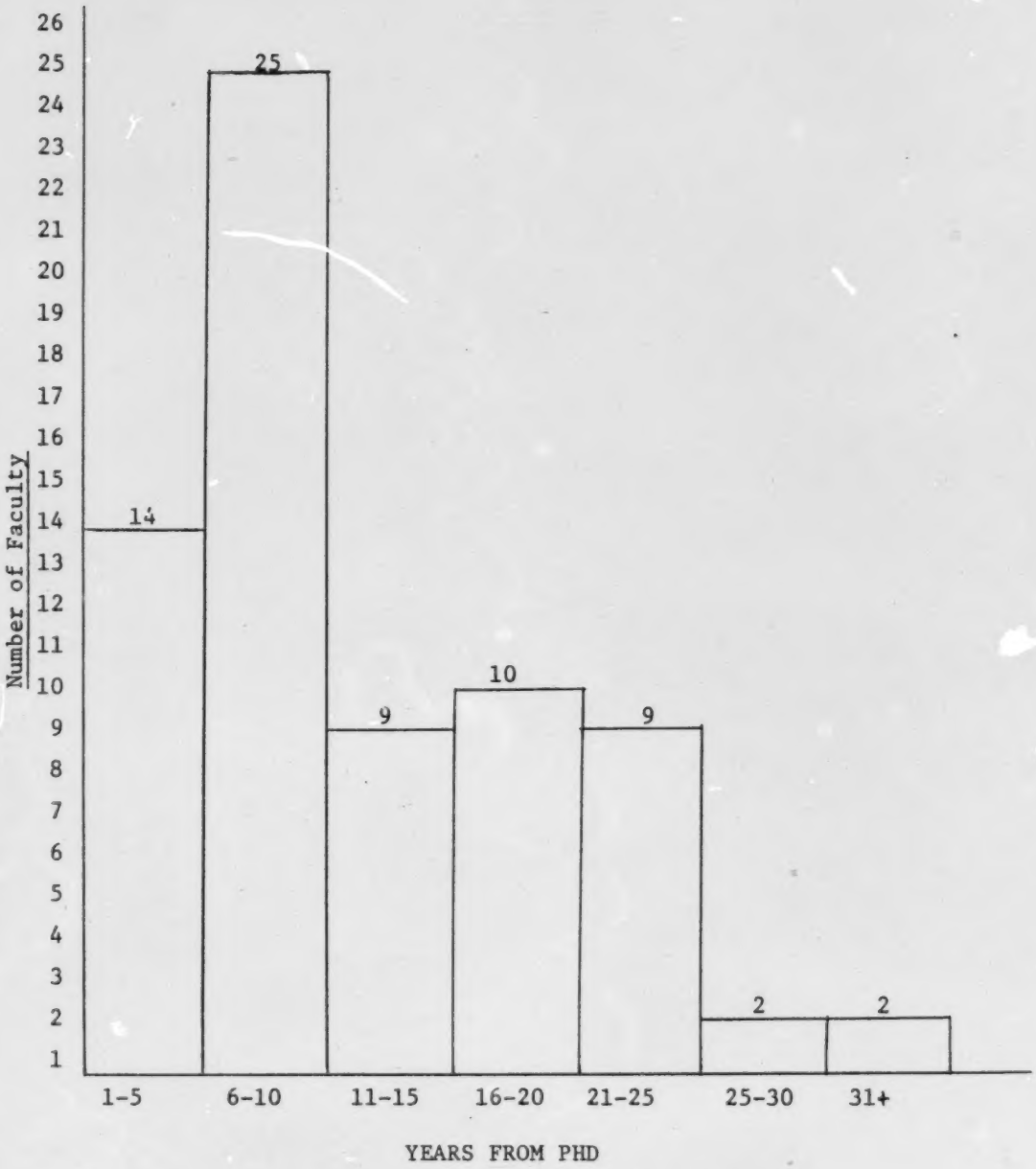
B. Faculty Quality and Quantity: As pointed out above, none of the departments involved in biophysics training can be classified as being numerically strong and the exact numerical strength is difficult to ascertain, since the majority of staff members have primary appointments not directly related to biophysics. For example, of the 32 staff members listed in Toronto only seven hold full-time university-salaried positions, the remainder being staff members of the Ontario Cancer Institute, the Hospital for Sick Children and the Toronto General Hospital. However, as a partial counter-balance to this argument, it must be pointed out that the student in biophysics, because of the interdisciplinary nature of his programme, may have access to a much larger number of staff members than those currently described as biophysicists.

If the quantity of staff is difficult to judge the quality is even more so without recourse to a detailed investigation of each department and staff member, a task which appeared beyond the scope of this discipline group. In attempting to judge quality the discipline group decided against utilizing evidence based on total grant support. It did this for several reasons. Since biophysicists work with a variety of biological systems with very different costs, such figures would be relatively meaningless since none of the departments are sufficiently large for meaningful intercomparisons and comparison with other basic science departments would also be meaningless. Nevertheless, figures made available by NRC suggest that biophysicists, the majority of whom are in Ontario, do well in their applications for research funding.

The data shown in Figures 1 and 2 give some information about the age distribution of the faculty on a province-wide basis (excluding Guelph) and also the publication record for the same individuals. Figure 1 indicates that the present faculty is relatively young in that more than 50% are within 10 years of obtaining their PhD and that less than 20% are more than 20 years beyond graduation - a distribution which is perhaps not unexpected given the relatively recent emergence of the discipline.

ACAP BIOPHYSICS STUDY

YEARS FROM PHD BY FACULTY
(Excluding Guelph)



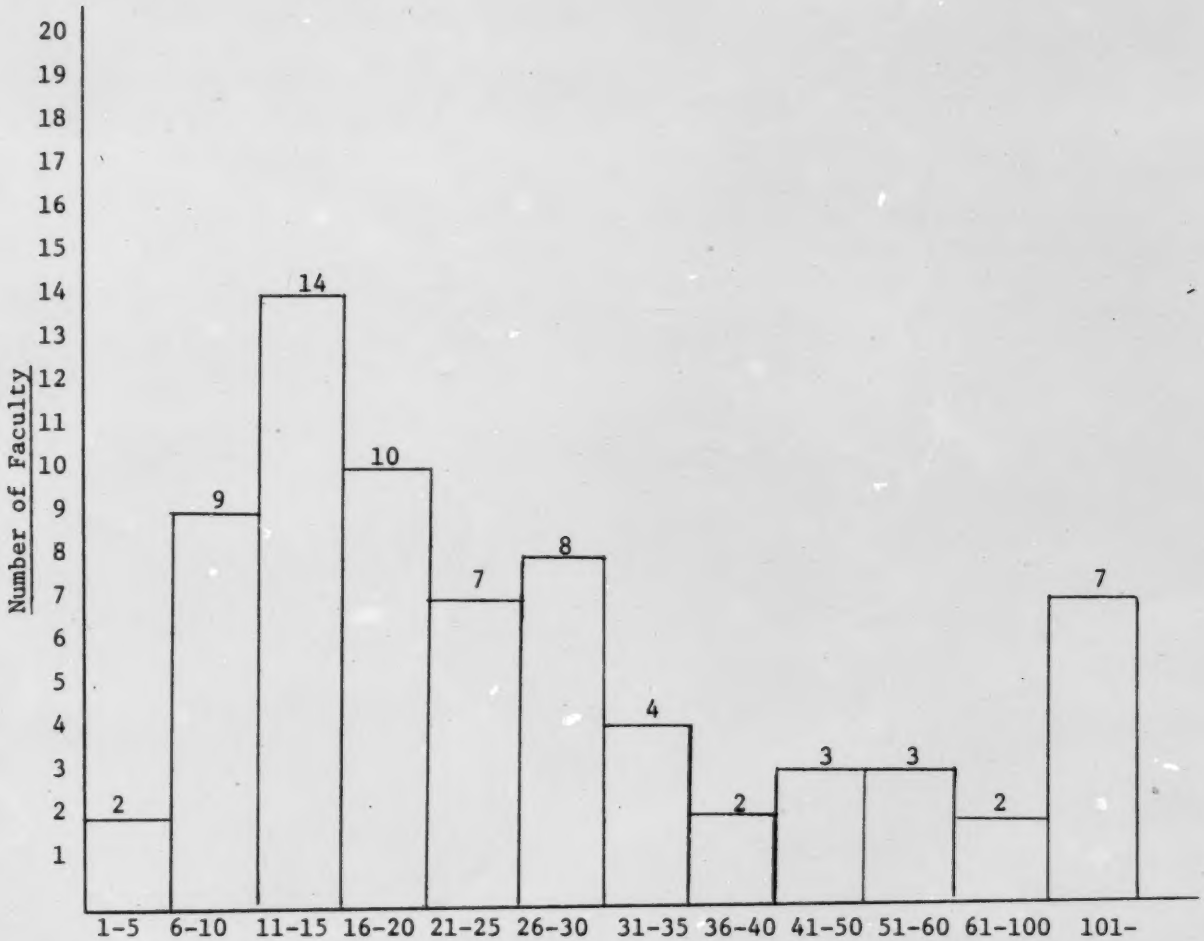
NOTE: Using 71 C.V.S.

November 29, 1973

FIGURE 1

ACAP BIOPHYSICS STUDY

PUBLICATIONS BY FACULTY
(Excluding Guelph)



NUMBER OF PUBLICATIONS

NOTE: Using 71 C.V.S.

November 29, 1973

FIGURE 2

The data in Figure 2 illustrate the publication record of the faculty but it must be stressed that since not all of the individuals have spent their entire careers in biophysics not all of these publications will be related to biophysics. Nevertheless, the figure is suggestive of a fairly active research group.

If the evaluation of individual staff quality is difficult, the evaluation of departmental quality is more difficult because, as pointed out above, many of the staff have competing responsibilities and one must therefore question their actual involvement in a biophysics programme. The question of critical size must also be born in mind in making such evaluations. In the past biophysics research has often centred around a single strong individual who became interested in applying his physics background to a biological problem. Such individuals have often been very successful and it would seem unwise to severely limit this possibility in the future, since to do so would hamper the gradual establishment of interdisciplinary groups, an evolution which appears increasingly important in the solution of many of the current problems in biology and medicine. It would therefore appear that for the present, a biophysics training programme might be centred around a single individual willing to make use of additional available expertise or around a group of individuals who have made strong commitments to the development of a cohesive programme.

> We therefore recommend that even single individuals of high research calibre should be allowed to supervise biophysics graduate students provided an adequate training programme can be guaranteed by an appraised group or department.

C. Nature of Programmes Offered: At the present time all of the universities listed in Table 1 provide programmes whereby physicists can be accepted into biologically-oriented graduate training programme but not all have programmes leading to a formal degree in biophysics, and therefore it seems advisable to briefly describe the situation existing in each university.

1. Brock: A graduate programme in biophysics at the master's level has been offered by three faculty members as part of an MSc degree programme in cellular and molecular biology with the main emphasis on membrane structure and function, muscle structure and function, and molecular developmental biology.

   At the present time there is no PhD programme.

2. Carleton: At the present time there are no formal MSc or PhD programmes in biophysics although formal courses have been given on occasion and one MSc student in biology and one MSc and 1 PhD student in physics are currently involved in biophysics research.

Carleton is contemplating an MSc programme in biophysics but has abandoned plans for a PhD programme. Current activities are in cell physiology, membranes and radiography.

3. Guelph: Although Guelph has at present an honours undergraduate degree programme in biophysics there are no formal programmes leading to a graduate degree in biophysics. A brief for appraisal has been prepared which includes a list of research interests. At present, graduate students in biophysics work for degrees in physics, chemistry or biological subjects.

4. McMaster: At the present time the only formal degree in biophysics is the MSc but biophysics students may also proceed to the PhD in biology. The primary research interests are in the fields of virology, protein structure, properties and synthesis of macromolecules, radiation damage, and repair.

5. Toronto: This department offers programmes leading to both the MSc and PhD with primary research interests in the fields of radiation biology, radiation physics, radiation chemistry, cell biology, cellular differentiation, immunology, medical and somatic cell genetics, bacterial and animal virology, structure and function of macromolecules and viruses, clinical physics, and nuclear medicine.

6. Waterloo: At the moment there is no formal degree in biophysics but both MSc and PhD degrees in physics are awarded to students enrolled in the biophysics programme. Primary research interests are in radiation biology, biophysics of freezing damage to mammalian cells, membranes.

7. University of Western Ontario: This department offers programmes leading to both the MSc and PhD degrees. Primary areas of interest include biomechanics, hemodynamics, cell biology, oxygen transport and metabolism, biological energetics, enzyme kinetics, control systems, contractile systems, nerve membranes, radiation biology, and dentistry.

8. York University: At the present time York has no formal programmes in biophysics but the department does attract students with strong backgrounds in the physical sciences. The present interests of the group related to biophysics include microbial genetics, genetic control mechanisms, DNA repair, radiation biology, mutagenesis, and enzymology.

D. Enrolment and Distribution Amongst Universities: Table 2 shows the number of biophysics students enrolled in MSc and PhD programmes by university as of October 1st for the last four years. From the figures several features are apparent:

1. In both categories the Universities of Toronto and Western Ontario account for the majority of students enrolled.

TABLE 2

ENROLMENT BY DEGREE AND BY UNIVERSITY

		Brock	Carl-eton	Guelph	McMaster	Toronto	Water-loo	Western	York	Total
MSc	1970-71	2*	-	3*	2	14	5*	9	6*	41
	1971-72	2*	1*	2*	3	17	3*	12	8*	48
	1972-73	3*	1*	2*	1	19	3*	9	4*	42
	1973-74	1*	2*	5*	-	18	3*	15	4*	48
PhD	1970-71	-	-	-	2*	40	3*	10	2*	57
	1971-72	-	-	-	2*	38	4*	16	2*	62
	1972-73	-	1*	2*	2*	29	2*	16	7*	59
	1973-74	-	1*	2*	2*	25	1*	15	5*	51

TABLE 3

GRADUATION BY DEGREE AND BY UNIVERSITY

		Brock	Carl-eton	Guelph	McMaster	Toronto	Water-loo	Western	York	Total
MSc	1970-71	-	-	-	-	6	3*	1	-	10
	1971-72	1*	1	2*	2	5	3*	4	4*	22
	1972-73	1*	-	-	2	1	1*	-	2*	7
PhD	1970-71	-	-	-	1*	3	-	3	-	7
	1971-72	-	-	-	-	12	1*	5	-	18
	1972-73	-	-	-	2*	4	1*	1	1*	9

Conclusions MSc Toronto and Western Ontario > 50%

PhD Toronto and Western Ontario > 50%

Graduates MSc about 12/year

PhD about 12/year

* Refers to students whose formal degree will be in biology, chemistry or physics but where, in the opinion of the discipline group, the subject material is considered as biophysics.

2. The number of MSc students enrolled appears to have stabilized at between 40 and 50 students per year.

3. In the case of the PhD candidate it is not clear whether the enrolment has stabilized or whether there has in fact been a significant decline over the last three years. Part of this apparent decline may be due to an abnormally high number of PhD graduates at the University of Toronto during 1971-72 (see Table 3). Another reason for the decline may be that an increasing number of students may decide to terminate at the MSc level on the assumption that employment will be easier.

Table 3 shows the number of MSc and PhD graduates by university. Since the numbers are small and therefore subject to relatively large random fluctuations, trends are difficult to evaluate. It would appear that on the average there are at present about 12 graduates per year at both the MSc and PhD level. A comparison of the average MSc enrolment with the annual rate of graduation appears to suggest that students are taking an inordinate time to complete the MSc degree. This calculation is not valid because it is the standard practice to register all candidates for the MSc and a number of these are ultimately reclassified for the PhD without completing a formal MSc programme. If we deal only with data taken from the University of Toronto biophysics programme, this shows an average of 25.6 months from BSc to MSc and an average of 55.7 months from BSc to PhD. It is our feeling that in general, biophysics training programmes will be somewhat longer than the average because most students are changing disciplines and therefore require more background training.

> We therefore recommend that the average time for an MSc or PhD in biophysics be recognized to be slightly greater than for monodisciplinary situations.

E. Admission Requirements and Quality of Student Body: In general the admission requirements to the MSc and PhD programmes of all of the departments are the same. For the PhD, the student will normally possess either an MSc or MD degree or an upper second-class honours degree in one of the basic sciences.

It is always difficult to determine the quality of a body of graduate students and perhaps the only easy measure to apply is to determine the number of students in the programme who have been able to obtain fellowships in open competition. The results of such a survey carried out at Waterloo, Western Ontario and Toronto indicate that of 8 students enrolled at Waterloo, 5 have had NRC Fellowships and 2, Province of Ontario Graduate Fellowships. At the University of Western Ontario, 22 students have received fellowship support and 28 have been supported from research grants. At Toronto, of 89 students surveyed, 35 have held National Cancer Institute of Canada

Fellowships, 12 MRC Studentships, 3 NRC Centennial Fellowships, 7 NRC Fellowships, 2 Commonwealth Fellowships, 4 have received fellowships in other national competitions and the remaining 26 have received either POFGs or have been supported from research grants.

While it may be said that ability to generate fellowship support is not a perfect measure of student quality, the fact that such a large percentage of biophysics graduate students do have fellowship support does suggest that many students who have a choice of graduate departments are choosing biophysics.

F. Relationship to Related Disciplines: It is apparent that with the exception of the programmes at Toronto and the University of Western Ontario which are self-contained departments, all of the other programmes are options either in biology or physics departments. In the former two departments, the affiliated staffs are probably sufficiently large that close liaison with other departments is not mandatory. However, even in these situations in order to reduce duplication of teaching and to make use of expertise in other departments a great deal of the students' didactic education is obtained in other departments. In the remaining departments, the biophysics programme is housed within either the physics or biology department and major use is made of the available expertise in these and related departments. Probably the only essential interactions required are that students with an undergraduate training in the physical sciences must be assured of adequate contact with research biologists and students with an undergraduate training in biology must be assured of some contact with the physical sciences. In short, biophysics is a discipline concerned with the solution of biological problems and the key requirement is that the student be given adequate training for quantitative research in biology with the recognition that the amount of contact with the physical or biological sciences will vary greatly with the individual. For these reasons, it is difficult to specify minimum amounts of interdepartmental interactions.

G. Physical Facilities: Biophysicists in general adopt one of two approaches in their research. Probably the most productive is to choose a significant problem and to bring to bear whatever approaches and techniques are required for the solution of that problem. The second and probably less desirable approach is where the individual is an expert in a particular technique, NMR, electron microscopy, etc. and attempts to apply this technique to the solution of a variety of biological problems. The first approach usually requires only relatively standard equipment common to most biological research institutions, with only occasional and temporary use of highly sophisticated equipment. The second may require a highly specialized piece of equipment for long periods of time.

Because it is difficult to draw up a meaningful and brief summary of the available equipment and library facilities available in all of the departments, the statements provided by the various departments are included in Appendix I.

H. Employment Opportunities: Table 4 lists the first employment after graduation for students obtaining a PhD during the years 1969-70, 1970-71 and 1971-72. Since the total number of graduates is small it is hard to draw statistically valid conclusions. However, several tentative conclusions may be drawn.

1. None of the graduates were known to be unemployed at the time of graduation.

2. The majority of graduates go on to a postdoctoral fellowship.

3. While a number go into hospital situations initially, relatively few enter either industry or government institutions.

Although no actual information was collected on the ultimate employment of these individuals it is our feeling that they have easily found employment in a diversity of science related positions.

While the unemployment level of PhDs is, in general, low this situation is probably even better for biophysics graduates because, in general, they will have demonstrated ability in several disciplines (usually physics and biology), they will have demonstrated a willingness to change disciplines or attack a variety of problems and, as pointed out in section (E), the quality of students is, in general, quite high. It is becoming increasingly obvious that the biological problems which face society are so complex that research in these areas requires in the investigator an ability to recognize and utilize the implications of physics, chemistry, biology and engineering both in the areas of research and development, and an extremely high degree of sophistication, involving a broad understanding of physics, chemistry and biology. For these reasons, the employment situation for biophysics PhDs may be expected to improve as more and more employers in government, industries and universities recognize the potential role of biophysicists. We therefore feel that it is important that the present number of PhD graduates be maintained and, if the quality of students and the ability to supervise them warrants, be allowed to increase with a review after a period of about 5 years.

TABLE 4

EMPLOYMENT OF PHDS 1969-72

	1969-70	1970-71	1971-72	1972-73*	Total
University			1	1	2
Industry					
Government					
Community College or High School					
Fellowship	6	2	11	3	22
Research (other than Fellowship)		1	2		3
Hospital	1	2	2		5
Other	1	1	1		3
Unemployed					
Unknown		1	1		2
Total	8	7	18	4	33

* Not including Toronto and York

While this report is primarily concerned with PhD programmes, it seems reasonable to comment on the employment prospects for those who graduate with an MSc. For these individuals the employment prospects also appear reasonably bright. Those with training along more clinical lines can often find employment in hospitals where they are prepared to take on more service-oriented functions. In addition, because biophysics training covers a variety of disciplines, MSc graduates have had experience not only in biological research but often also as physicists with an orientation towards quantification and instrumentation. For this reason they make excellent technical associates and are in demand in research groups. It might also be expected that the broad training required of a biophysicist would

make these individuals highly qualified as high school science teachers. That relatively few individuals follow this route may however, reflect the high demand in other areas or their unwillingness to undertake formal teacher training relatively late in their careers.

One additional factor which may have some bearing on the future employment of MSc and PhD biophysicists is the increasing demand in hospitals for individuals who are service-oriented and who would be available to maintain and develop the highly sophisticated equipment now available in most hospitals. The need for such individuals has been recognized by the Government of Ontario and a task force is at present drawing up recommendations. Finally it has been pointed out that the present concern with ecology will increase the demand for scientists in this area - a role for which biophysicists may be admirably equipped since they will be in an excellent position not only to design equipment for physical monitoring but also to understand the biological implications of these measurements.

We therefore recommend that for the next five years no ceiling be placed on the total number of graduate students enrolled in biophysics.

I. Relationship to Biomedical Engineering: It is the feeling of the discipline group that biophysics and medical engineering form part of a scientific continuum. On one side they are primarily concerned with the development of engineering solutions to biological or medical problems. As a result they are primarily concerned with instrumentation. On the other side they are primarily interested in using the methods and concepts of physics in the solution of biological problems - solutions which may but very often will not involve the design of new equipment.

Because the two disciplines have areas in common they should attempt where possible to arrange liaisons in an attempt to reduce unnecessary duplication. It would, however, seem unwise to attempt a totally joint programme because the diversity is greater than the commonality.

J. Possible Areas of Cooperation: In considering potential areas of cooperation consideration must be given to the utilization of both staff and facilities for teaching and research. Many biophysicists do not require highly expensive pieces of specialized equipment, such as is required in some areas of nuclear physics, but make use of a range of equipment found in most good biological or physical research laboratories. In a number of areas, however, sophisticated and individually designed equipment is required or could be used on an infrequent basis and here cooperation would be desirable.

It is in the area of graduate teaching that cooperation would be most desirable but perhaps difficult to obtain. It has been pointed out that biophysics has developed and often remains centred around individuals or small groups interested in a restricted area within this broad discipline. Indeed, the data of this study indicate that few Ontario universities have built large self-sufficient programmes; most of them have small groups of biophysicists. Taken together these groups constitute a valuable scientific resource in the province which could be exploited by developing cooperative training programmes where students would be exposed to a greater breadth of offerings.

While there are practical difficulties of time and distance to be overcome, the feasibility of such cooperative teaching programmes has already been demonstrated: an inter-university graduate biophysics course involving approximately twelve students per year has been given by Brock, Guelph, McMaster, and Waterloo for the past two years. It should be possible to expand from this base if the universities wish to do so. Such expansion could take the form of summer institutes, workshops or intensive courses for which faculty and students shift their base of operation for a short time.

Because of the tendency for biophysicists to operate in small groups, several Ontario universities have the research capability, although not the formal programme to supervise students in biophysics at the PhD level. In such cases, arrangements should be developed whereby supervision of graduate students can be carried out on a cooperative basis. It must be stressed, however, that a cooperative programme should only be an adjunct to good biophysics research within the participating universities.

The above proposals would encourage the best use of biophysics staff and facilities and enable small but well qualified groups to participate in graduate student training.

We therefore recommend that:

1. Interested universities develop interuniversity cooperation, particularly in the area of the formal teaching programme of graduate students in biophysics.
2. Qualified individuals or small biophysics groups in universities without appropriate PhD programmes be enabled to supervise PhD candidates in cooperation with an appraised group or programme subject to conditions that include the following:
   (a) the candidates meet the academic requirements of the degree-granting university.
   (b) the supervisory committee of the student include faculty from both universities.
   (c) residency requirements be modified, if necessary, to allow the candidate's research to take place on his supervisor's campus.
   (d) there be a fair sharing of costs and income.

III. Future Graduate Training Programme

As we have pointed out earlier, much of the biophysics being carried on in Ontario universities is the work of relatively small groups. With a few notable exceptions, there is relatively little long-term commitment to particular biophysical research problems on any campus. At the present stage of development of the subject we do not expect such a specific emphasis to be desirable. Consequently there must be ample scope for the work of individual laboratories to evolve according to the interests and interactions among individual researchers.

In the introduction we described the breadth and diversity of biophysics, with regard to subject matter, techniques employed and the type of scientist attracted to this field. This makes it difficult either to forecast future trends in detail or to define the future role of every department. Moreover since the whole field has not yet been covered in Ontario (and indeed it is not practical to cover it fully with the available effort) it would be premature to attempt such a task. Thus, we would expect new areas of biophysics to be developed in a natural way, that is, in accordance with the internal logic of the subject. Provided these developments occur in departments or groups qualified in biophysics, we anticipate that graduate students will take part in this advancement of the frontiers of the subject.

Because biophysics uses physical techniques and ideas to solve biological problems, the interdisciplinary connections are of special value. We foresee a continuing, and possibly an increasing desire on the part of biology and physics departments to become involved in biophysics and feel that this kind of activity is to be encouraged. It seems unlikely, however, that this will lead to any duplication of effort, partly due to the breadth and diversity referred to above and partly because of the natural exchange of information occurring among the members of the Ontario biophysics community.

The enrolment of MSc and PhD students over the past 5 years was given in Table 2. An informal estimate was made by the discipline group of the trends in enrolment over the next 5 years and these forecasts are shown in Table 5, compared to the mean for the past two years.

TABLE 5

FIVE YEAR FORECAST OF GRADUATE ENROLMENT
IN MSC AND PHD PROGRAMMES IN BIOPHYSICS

University	MSc plus PhD Numbers	
	1972-74 Mean	1977-78
Brock	2	3
Carleton	2 1/2	2
Guelph	5 1/2	28
McMaster	2 1/2	5
Toronto	45 1/2	50
Waterloo	4 1/2	5
Western Ontario	27 1/2	30
York	10	12
Total	100	135

The proposed increase for the whole system is about 35%; for all universities other than Guelph the increase is about 12% and the increase due to the programme proposed at Guelph represents about 23%. We note that the Guelph programme is expected to attract some students of different backgrounds from those entering existing major programmes. In addition we expect a general rise in student enrolment because of the rising interest in biophysics discussed in section II. For these reasons, we believe that the enrolment forecasts in Table 5 are reasonable and, moreover, are consistent with the needs foreseen in II. H.

We therefore recommend that:

1. The distribution of students among qualified training programmes be allowed to evolve in a natural way.
2. There be no assignment of specific research areas to specific departments.
3. The discipline group review student quality and programme areas at reasonable intervals.

IV. Summary of Proposal by the University of Guelph

The University of Guelph has put forward a proposal for an interdepartmental PhD programme in biophysics. Although the Physics Department plans to develop this programme and is largely responsible for it, ten other departments are also involved. The programme is different from any other in Ontario because of its emphasis on complex physical techniques and because of its association with the Ontario Veterinary College (there are only two of the latter in Canada) and the Ontario Agricultural College. The future directions of this programme in the Physics Department involve emphasis on theoretical and environmental biophysics since these (especially theoretical biophysics) naturally grow out of recent developments in theoretical physics and chemistry. It is believed that all areas of biophysics in Ontario are still underdeveloped but this is especially true for theoretical and environmental biophysics.

Presently, the University of Guelph grants the following degrees where the area of specialization can be biophysics, (1) BSc degree in honours biophysics and honours biochemistry, (2) MSc degrees in physics, chemistry or zoology, (3) PhD degrees in chemistry and zoology, (4) PhD degrees in physics offered only in collaboration with the Physics Department at the University of Waterloo. The MSc programme has been operating for about four years and so there is a pool of potential PhD students. Biophysics graduate training is organized by interdepartmental groups at the present time, and the students are located in the department of the supervisor.

The five-year plan of the biophysics group is ultimately to have about 12 PhD and 16 MSc students. A more detailed proposal is contained in the "Brief for Appraisal" and the discipline group has examined this.

We therefore recommend that:
Since there is little overlap between the biophysics PhD programme proposed by Guelph and those of other Ontario universities and since both the number of prospective students and the demand for graduates appear to warrant an expansion of biophysics training, the proposed MSc and PhD programmes in biophysics at the University of Guelph be started after a successful appraisal.

APPENDIX I

PHYSICAL FACILITIES

Included here are the statements supplied by each university describing their physical facilities.

BROCK: Special laboratory facilities include three X-ray generators, one microfocus rotating anode, six X-ray cameras, laser optical diffraction, physiological electronics and recorders, a Phillips 300 electron microscope, a Packard tri-carb scintillation counter, a Gilson automatic UV-visibl[illegible]cording spectrophotometer. Supportive facilities include a full range of chromatographic and electrophoretic techniques, preparative ultracentrifuges, cold rooms and most routine biochemical facilities. A Burroughs 5500 computer exists in the University for research and student use. At present we are collaborating with the physics and chemistry departments in the use and development of a laser-Raman Spectroscopy facility.

The main library carries some 175 periodicals in the biological sciences and most of the main indexing and abstracting journals of application to research in biology and physics. Specific library resources of 1968 are fully documented in our appraisal submission for an MSc programme in cellular and molecular biology. Since then a core of journals relevant to the departmental interests in biophysics has been improved upon and developed. We seldom need to resort to interlibrary loan services in this area.

CARLETON: No material provided.

GUELPH: See proposal for appraisal.

McMASTER: Dr. Brown's research is carried out with the X-ray diffraction facilities maintained by the Departments of Chemistry and Physics and the Institute for Materials Research Space and facilities are adequate; equipment includes X-ray and neutron single crystal diffractometers, an X-ray liquid diffractometer and computer programmes for determining crystal structures of small biological molecules.

The research of the other 5 members of the group is carried out in the new Life Sciences Building, which is well equipped with ultracentrifuges, scintillation counters, an electron microscope facility, a 2000 curie ^{137}Cs source, as well as other biochemical and biological equipment normally required for molecular biophysics. Equipment for studying fast reaction kinetics is being built by Dr. Morton. Space is adequate. (Space and facilities in the Life Sciences Building are, of course, used by other faculty members and students in the Department of Biology, besides those being discussed here.)

Additional equipment is available in other departments. This includes a CDC 6400 computer, the nuclear reactor, the tandem accelerator, magnetic resonance spectrometers (the one at Sheridan Park would be the most useful for biological molecules), and electron paramagnetic resonance spectrometers.

Library resources are adequate for both journals and books in molecular biophysics.

TORONTO: Space Resources: The department in effect has no space under its direct control since all of the space is either the property of the Ontario Cancer Institute or is under the control of the undergraduate department of Medical Genetics. Nevertheless the space effectively available for graduate training is certainly adequate for any present or proposed graduate training programme in the department.

Laboratory Facilities: It seems fair to describe the laboratory facilities available as excellent although as described above a large part of the facilities are the property of the Ontario Cancer Institute. The equipment and facilities available include a betatron, 2 linear accelerators, cobalt 60 and conventional X-ray facilities, 3 electron microscopes, ultracentrifuges, liquid and conventional scintillation counters, monochromators, a range of computer facilities including both the university and OCTRF time sharing computers, electronic and machine shops, media facilities, photographic darkrooms, etc.

Library Resources: In addition to free access to the University of Toronto library facilities, the Ontario Cancer Institute has a library containing approximately 14,000 volumes and subscribes to 300 current scientific and medical periodicals.

WATERLOO: The Department of Physics owns two computers which we use extensively. All the necessary laboratory facilities are available either in our own laboratories or in laboratories of colleagues in biology, chemistry or physics and we have easy access to all of the latter.

The library facilities are adequate as Dr. W. F. Forbes and the Department of Biology have built up a fine collection before any of the biophysicists arrived on campus. In addition, interlibrary loan service is speedy and efficient in the Ontario universities.

WESTERN ONTARIO: Very short of space - 4,150 square feet in department in the Medical School. Drs. Roach, Boughner, and Ferguson each have one small laboratory at University Hospital. Drs. Sutherland and Inch are at Victoria Hospital in the Ontario Cancer Foundation Clinic.

Dr. Miller is in Agricultural Research and has one student. Other honorary lecturers have no students at present, but do co-supervise.

Two terminals to University computer (one for Sherebrin's work and the other shared); E.S.R. (Taylor); I.R. spectroscopy, electromagnetic and ultrasonic flowmeters; isotope counters; tissue culture apparatus; three micromanipulators; time-lapse photography with analyzing projector; recorders, etc.; automatic Wilhelmi balance.

Medical library - excellent; science and engineering libraries provide the rest.

YORK: As has been noted York University has no biophysics programme as such, but has a number of faculty members who carry out research which could fall under the heading of biophysics and/or have received graduate degrees in biophysics. The information presented here will therefore pertain to this set of faculty within the Biology Department, which itself presently offers a graduate programme in biology.

The space is adequate for the programme, although under the present arrangement there is limited room for expansion.

Laboratory facilities are adequate and include the normal major items of equipment, such as scintillation spectrometers, ultracentrifuges, spectrophotometers, etc. York University has adequate computer facilities.

The Steacie Science Library has an adequate collection of research journals, research monographs, reference books and review series. The collection of journals could, perhaps, bear expansion with regard to duplication of much used journals and addition of new titles, and within budgetary limitations this is proceeding.

A P P E N D I X B

UNIVERSITY COMMENTS

Comments appear from Brock, Carleton, Guelph, McMaster, Toronto, Waterloo and Western Ontario.

Biophysics
BROCK UNIVERSITY

The report of the discipline group provides a clear account of the status of biophysics within the province. The recommendations appear to be a natural development of the textual material and in accord with reasonable expectations of student interest, social need and scientific advances for the next five to ten years.

Brock University has a particular interest in the recommendations contained in Section IIJ regarding inter-university cooperation. Action to develop these recommendations into practice would be most beneficial to an institution of modest size in the ongoing development of its faculty. At the same time such cooperation would provide for the most effective use of the widely dispersed resources in biophysics within Ontario.

CARLETON UNIVERSITY

RESPONSE TO THE BIOPHYSICS PLANNING STUDY

In general, Carleton supports the conclusions and recommendations contained in the report of the Biophysics Discipline Group. We would, however, like to comment on two matters raised in the report.

Recommendation on Page A-8

We find this recommendation open to different interpretations. What is meant by "an appraised group or department"? This could mean a Biophysics group or department in a different institution, or a related (not Biophysics) group or department in the same or a different institution. We are also uncertain as to what is meant by the word "guaranteed" in this recommendation. We would suggest that this recommendation be re-phrased to make it more explicit.

Cooperative Arrangements, Page A-16

We support the principle of cooperative arrangements between and among universities but we feel that the principle should be broadened to include cooperative arrangements among universities and research groups outside the universities, particularly with groups in government laboratories. Carleton already has such arrangements and would wish to continue these and to strengthen and expand them.

G. R. Love
November 20, 1974

University of Guelph

Comments on Biophysics Planning Study

The Discipline Group has presented a statement concerning biophysics which is generally consistent with our understanding of what is involved. Furthermore, it is within this context that Guelph has been developing its undergraduate program and planning for its proposed graduate programs currently undergoing Appraisal.

We are, therefore, gratified that the Discipline Group recommends that Guelph proceed after a successful appraisal. We look forward to the acceptance of that recommendation by ACAP and COU. We note, in passing, the favourable position taken by COU with regard to our Ph.D. program in Physics, successfully appraised in 1970 but placed under embargo in early 1971 before any students could be enrolled. It is our hope that these programs may go forward as a contribution to province-wide doctoral studies in these important fields.

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October 24, 1974

McMASTER UNIVERSITY

DEAN OF GRADUATE STUDIES

SCHOOL OF GRADUATE STUDIES HAMILTON, CANADA L8S 4K1

October 30, 1974

Dr. M. A. Preston,
Council of Ontario Universities,
130 St. George Street,
Suite 8039,
Toronto, Ontario M5S 2T4.

Dear Dr. Preston:

I write in connection with the report on the Biophysics Planning study.

McMaster University is in agreement with the findings and recommendations of this Planning study. We are pleased to see that it is recognized that the term "Biophysics" is used to cover a wide range of activities including some which are shared by persons who do not regard themselves as biophysicists. In particular, we are pleased to see that it is recommended that even single individuals of high research calibre should be allowed to supervise biophysics graduate students provided that an adequate training program can be guaranteed by an appraised group or department. We intend to continue to support at this University a small group of biophysicists who will have graduate students working on biophysical topics as part of their graduate programs in biology, physics or other related areas. We also welcome the recommendations for inter-university cooperative arrangements in regard to the training of graduate students and the participation of faculty in doctoral degree supervision. As a university which has already participated in a cooperative graduate biophysics course, we stand ready to take part in appropriate new collaborative ventures.

Very sincerely yours,

Leslie J. King

Leslie J. King
Dean

LJK/del

UNIVERSITY OF TORONTO
School of Graduate Studies

OFFICE OF THE DEAN

Toronto 181, Canada

October 23, 1974

Dr. M.A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning
Council of Ontario Universities,
130 St. George Street, Suite 8039
Toronto M5S 2T4

Dear Dr. Preston:

The A.C.A.P. Biophysics Planning Study is on the whole a sound assessment of the present state of the discipline in Ontario. The discipline group is to be commended for its rejection of enrolment limitations and its recommendation that research areas and student distribution be allowed to evolve naturally rather than be arbitrarily fixed in advance. It is also to be commended, subject to the qualification in (3) below, for its recognition that "single individuals of high research calibre" can do valuable supervisory work in this particular field. Specifically, the University of Toronto concurs with the recommendations on pp. A-8, A-15 and A-18.

Our reservations concern the recommendations on pp. A-11 and A-16 and the figures given in the Planning Study for the number of University of Toronto faculty members involved in biophysics and for our enrolments in biophysics.

(1) As is apparently not the case for the other universities included in the Planning Study, the number given for University of Toronto faculty members working in biophysics does not include a large number of faculty whose work is in biophysics but whose university appointments are to the Faculty of Medicine and to departments such as Botany, Geography, and Zoology. The total number of our biophysicists should thus be about 50% higher than the figure of 32 given (A-4, A-5) in the Planning Study.

(2) The higher faculty figure, together with the fact that students doing doctoral work in biophysics in departments such as Botany and Zoology are usually not identifiable as biophysics students, and the likelihood that increased enrolment in biophysics in the next decade will probably come in those areas such as Botany and Geography where

biophysics is at present not highly visible, necessitates an upward revision of the Planning Study's current enrolment figures and projections for the University of Toronto. The present figures (pp.A-10, A-18) are unrealistically low.

(3) I hope that the recommendations on pp. A-16 concerning inter-university cooperation mean that students will register in the universities with approved degree programs, and that these universities will then be encouraged to utilize, insofar as is possible, qualified faculty members from other universities. Otherwise, I see very serious problems for students and universities. I am afraid that many of these recommendations on inter-university cooperation, while desirable in principle, tend to overlook serious problems in maintaining standards and in communication, travel, and finance.

We should finally like to note, in relation to the recommendation on p.A-8 that students benefit greatly from associating with other students, and that at the University of Toronto the Institute of Medical Science serves as a focal point for students and staff members working in biophysics. The Institute and the medical biophysics group hold weekly seminars which both range over the field of biophysics and facilitate staff-student contact.

Yours sincerely,

A.E. Safarian

A.E. Safarian
Dean

AES/mm

ADVISORY COMMITTEE ON ACADEMIC PLANNING
Ontario Council on Graduate Studies

Professor M. A. Preston
Executive Vice-Chairman

B-7

COUNCIL OF ONTARIO UNIVERSITIES
130 ST. GEORGE STREET, SUITE 8039
TORONTO, ONTARIO M5S 2T4
(416) 920-6865

November 27, 1974.

Dr. A. E. Safarian
Dean, School of Graduate Studies
University of Toronto
Toronto, Ontario.

Dear Dean Safarian,

In your letter of October 23rd, concerning the Biophysics planning study, you point out that the Discipline Group does not mention faculty members working on biophysical topics in other departments at Toronto. I believe we can write a satisfactory report on Biophysics without much detail of this kind and I am not writing to ask for further data, although we did send a draft copy of the Discipline Group report in June so that each university could point out factual errors or omissions.

However, there is one aspect on which we would like a little more information. The subcommittee preparing the ACAP report is inclined to feel that there should be a reference to Toronto indicating in what department such work is undertaken with the involvement of graduate students. We do not understand the reference to the Geography Department in this connection.

We would also appreciate some feeling for the magnitude of the increased enrolment which you foresee. Since you say that the "present figures are unrealistically low" it is important for us to know what you have in mind, if we are to compare the universities' expectations with likely enrolment.

Yours sincerely,

M. A. Preston /kw

M. A. Preston

MAP:edh

B-8

UNIVERSITY OF TORONTO
School of Graduate Studies

OFFICE OF THE DEAN

Toronto 181, Canada

December 12, 1974

Dr. M.A. Preston,
Executive Chairman,
Advisory Committee on Academic Planning,
130 St. George Street,
Suite #8039
Toronto

Dear Dr. Preston:

I now have the additional information you requested on work in biophysics at the University of Toronto. Areas of the university in which work on biophysical topics is at present being carried out, other than the Department of Medical Biophysics itself, are the Faculty of Medicine (Banting and Best Department of Medical Research; Department of Radiology) and the Departments of Botany, Geography, Physics, Physiology, and Zoology. Only one faculty member is so far involved in this kind of work in the Department of Geography; he is working in microclimatology, on the exchange of gases between plants and the atmosphere.

We anticipate an enrolment, by 1977-78, about 25% higher than the figure of 50 given on p. 22 of your report; this added increase should be entirely in the areas (named above) other than the Department of Biophysics itself.

Yours sincerely,

Anne Lancashire

Anne Lancashire
Assistant to the Dean

AL/mm

Response of the University of Waterloo to the Report of the Biophysics Discipline Group to the Advisory Committee on Academic Planning submitted to ACAP, November 1st, 1974

The University of Waterloo finds this report generally acceptable. As the report points out, graduate work in biophysics has developed in diverse ways in different institutions; in some being part of the programme in physics, in others part of the programme in biology and in still others being identified as a distinct programme in biophysics. This diversity arises from the nature of the subject itself and we support the thrust of this report which suggests that no attempt should be made to alter the course of development of this discipline. As the report states, there is very little overlap between existing programmes.

We also agree that no attempt should be made to curtail enrolment in graduate work in biophysics. Our own experience suggests that the number of qualified students wishing to study in this field is greater than the number that can be accommodated. At Waterloo, a very high percentage of the students in biophysics are Canadians and job opportunities for graduates of our programme are quite promising.

One matter of some regret to us is that the discipline group did not make any mention of related work in the field of biomedical engineering. It would have been helpful in obtaining a general overview of the field to have some mention of the inter-action between these two fields.

The section devoted to the University of Waterloo in appendix A which describes the physical facilities available to support graduate work in biophysics is incomplete. We append to this response, therefore, a more detailed listing of the facilities available at this university.

Respectfully submitted,

L. A. K. Watt

L. A. K. Watt
Dean of Graduate Studies

List of Major Equipment Available for Use by Biophysics Personnel at Waterloo

The equipment is located in the departments of Physics, Chemistry, Biology, and in the Faculty of Mathematics.

Beckman Model E Analytical Ultra Centrifuge,

Liquid Scintillation Counters,

Preparative Ultra Centrifuges,

Transmission and Scaning Electron Microscope,

Variety of Spectrometer Facilities including UV, Visible, IR, NMR, EPR and ,

137 Cesium Radiation Unit,

Amino Acid Analyzer,

Time Lapse Photographic Facilities,

Several Types of Computer Facilities,

X-ray Diffraction,

Separative Facilities such as Chromatography and Electrophoresis Equipment.

RESPONSE OF THE UNIVERSITY OF WESTERN ONTARIO

to the

REPORT PREPARED FOR ACAP BY THE BIOPHYSICS DISCIPLINE GROUP

This report has been prepared by a Committee of Senate charged with generating a response to the Biophysics Planning Study. The universities of this Province have now received from the Council of Ontario Universities, roughly a dozen reports outlining plans for graduate studies in difference disciplines, each of which has been prepared on the basis of a discipline assessment carried out by the Advisory Committee on Academic Planning. It is the stated intent of each report that its recommendations should serve as the basis for forward planning to ensure the ordered growth and development of graduate studies in Ontario universities. This report prepared by people within the Province working in the discipline concerned is, not unexpectedly, rather different in conception than are those which have been prepared by a set of external and independent consultants. It will, as a result, be of rather less benefit to ACAP and the universities in planning the future development of Biophysics in the Province.

We note with interest and offer comments upon the following recommendations taken from the report:

1. The recommendation on page A8 that single individuals be allowed to supervise Biophysics graduate students, seem to be unnecessary. If such an isolated individual has the appropriate back-up from an appraised group or program in the fashion outlined in points 1 and 2 on page A-16 , then the practice may be acceptable.

2. With reference to paragraph 1 on page A15 we recognize that highly trained individuals may be necessary to some activities occurring in hospitals. We nonetheless believe that graduate training programs should not identify as their aim and objective, the production of purely technical personnel.

3. The recommendation that for the next five years no ceiling be placed on the total number of graduate students enrolled in Biophysics, we view with some concern. This recommendation, along with the one recommending the establishment of a new Ph.D. program at Guelph, suggests that the demand for the graduates of these programs is, at present, sufficient to justify the 35% increase in enrolments over the next four years, anticipated in Table V.

4. While we generally endorse recommendations 1, 2, and 3, on page A18 we would like to see the student quality and program review carried out at specified intervals, preferably annually.

We hope these comments will be of some assistance to ACAP.

November 25, 1974.